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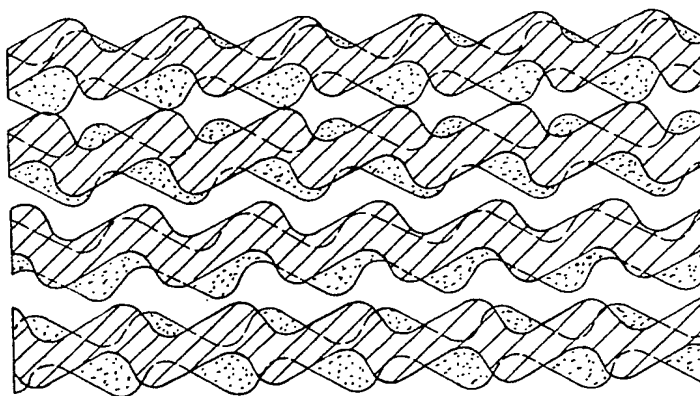
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(54) Gravure printing formes

(57) A gravure printing forme includes an ink receiving matrix formed by a number of lines each having a wavy configuration over at least part of its length, with the amplitude of the wavy configuration and the separation of adjacent lines being such that no overlap takes place between them.

Colour shifts or Moiré patterns on the printed product are avoided in multi-colour printing, when at least two of the formes for different colours are of this type, as shown for example by Fig. 7. When using a laser or electron beam for engraving the forme it is given a transverse oscillation during scanning movement.

Fig. 7.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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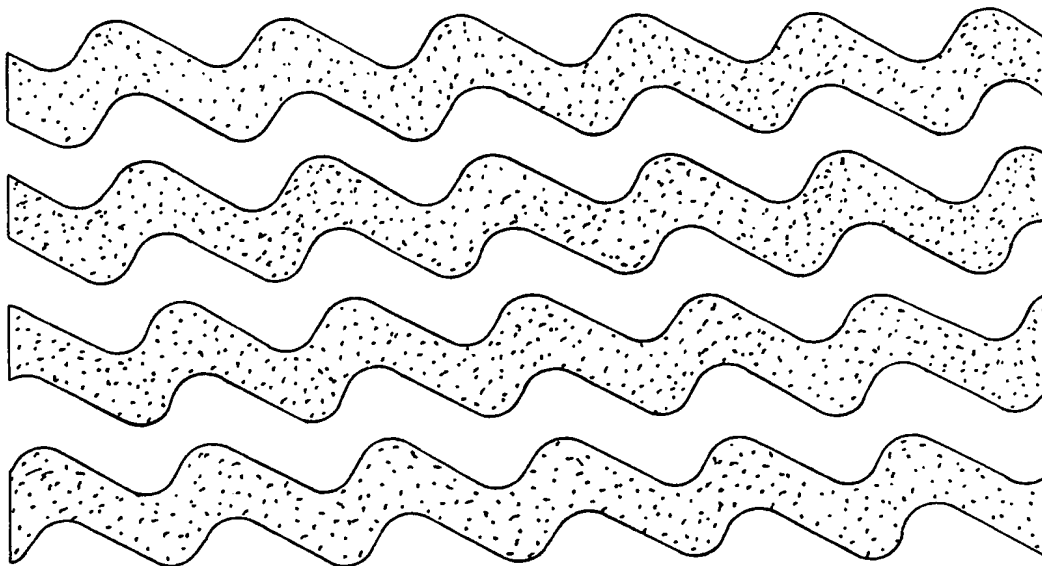


Fig .3.

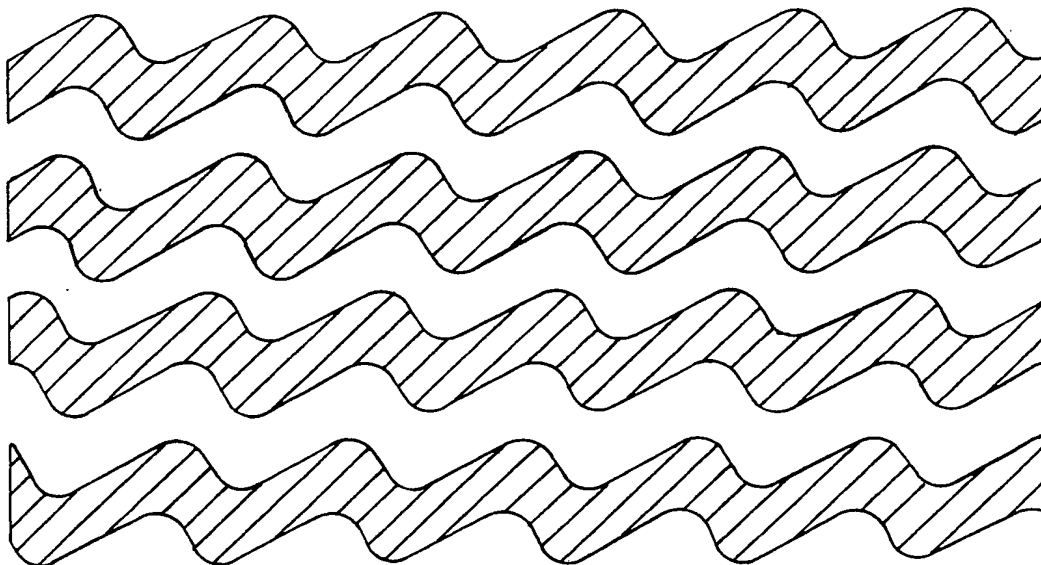


Fig.4.

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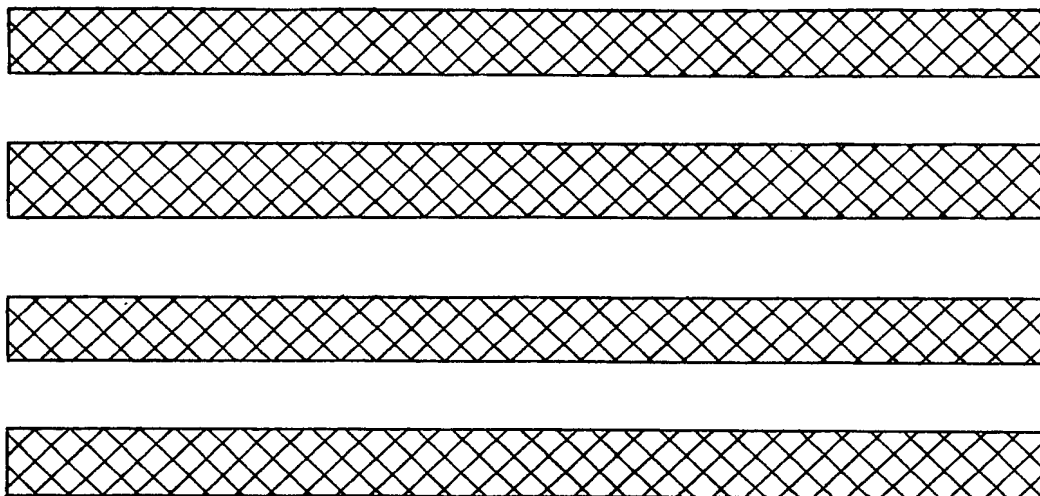


Fig .5.

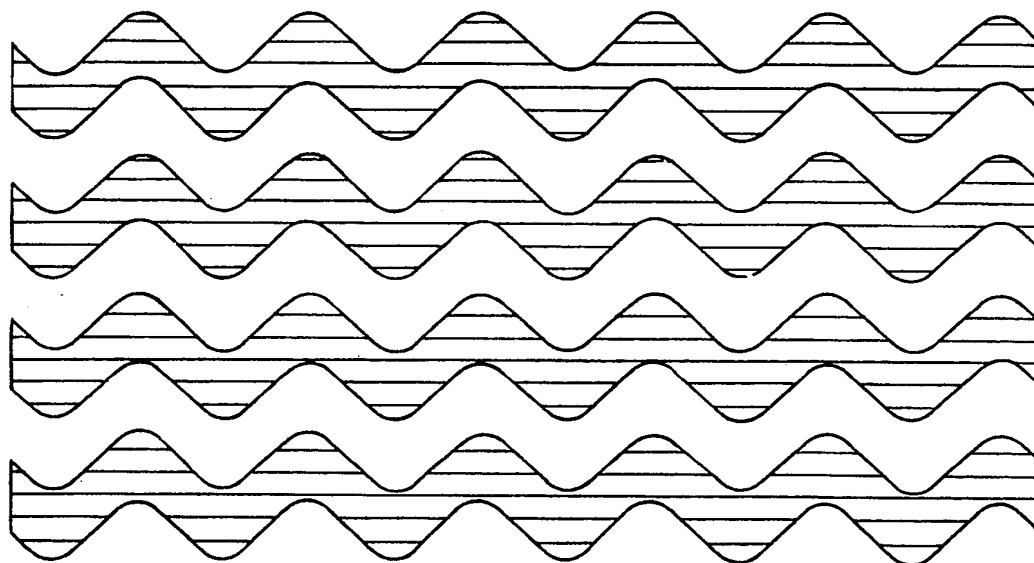


Fig .6.

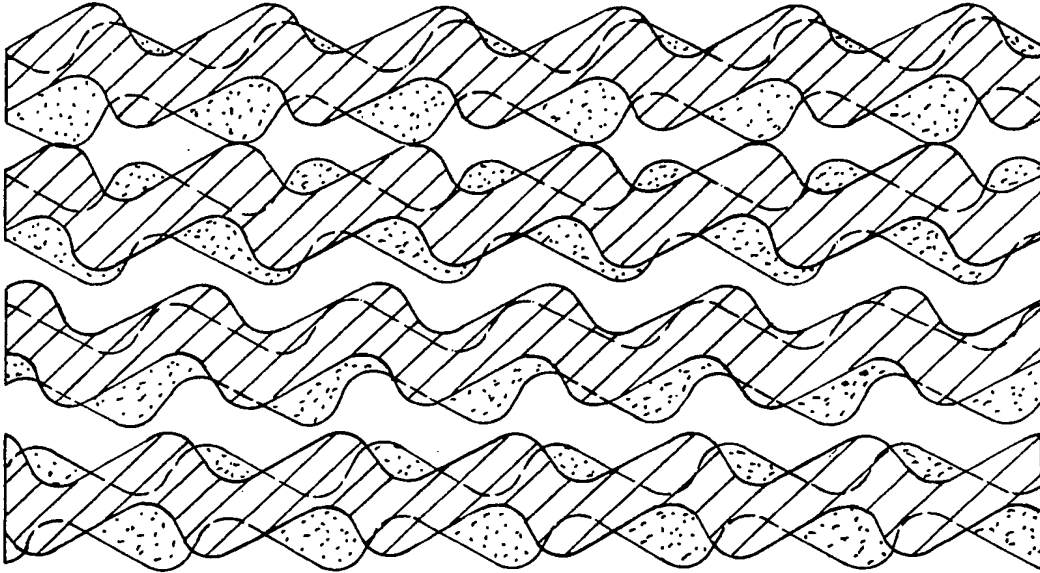


Fig. 7.

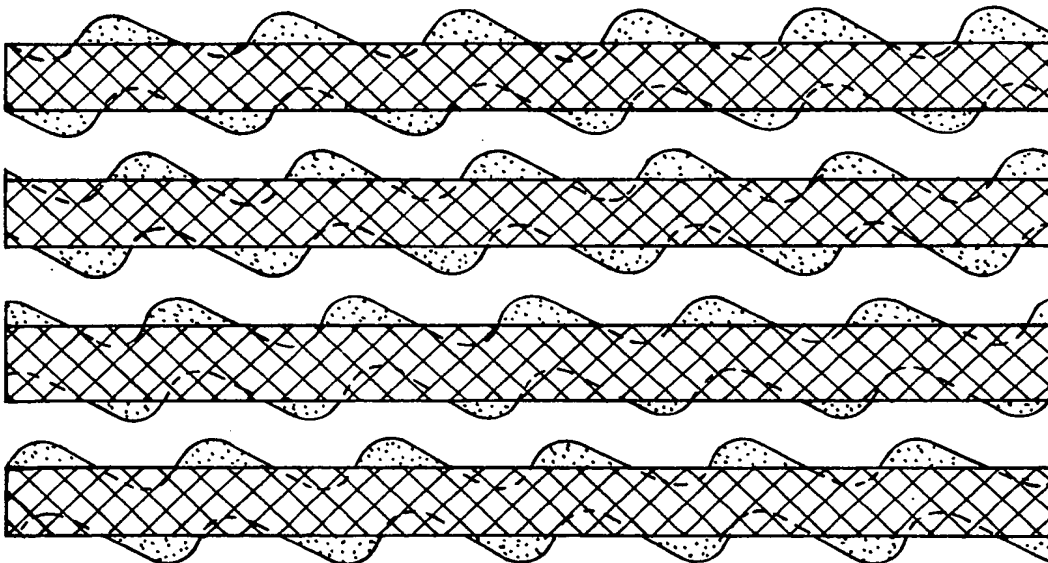


Fig. 8.

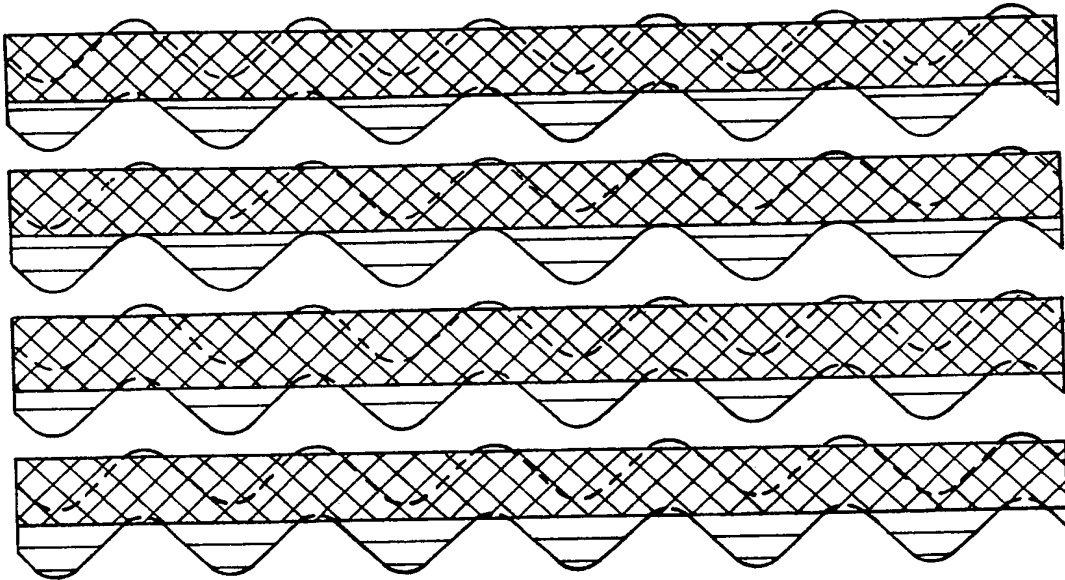


Fig .9.

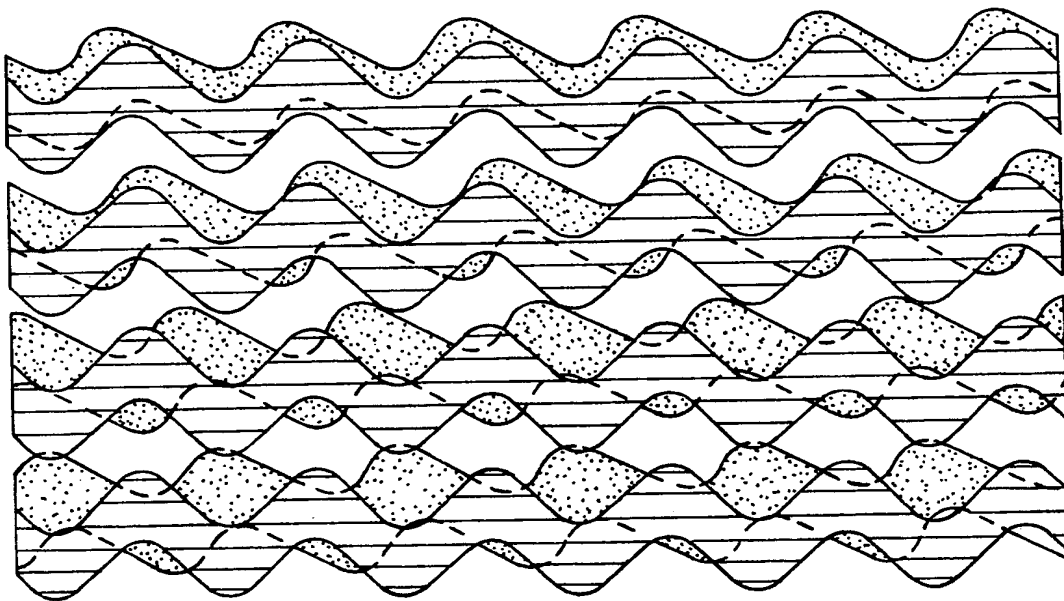


Fig .10.

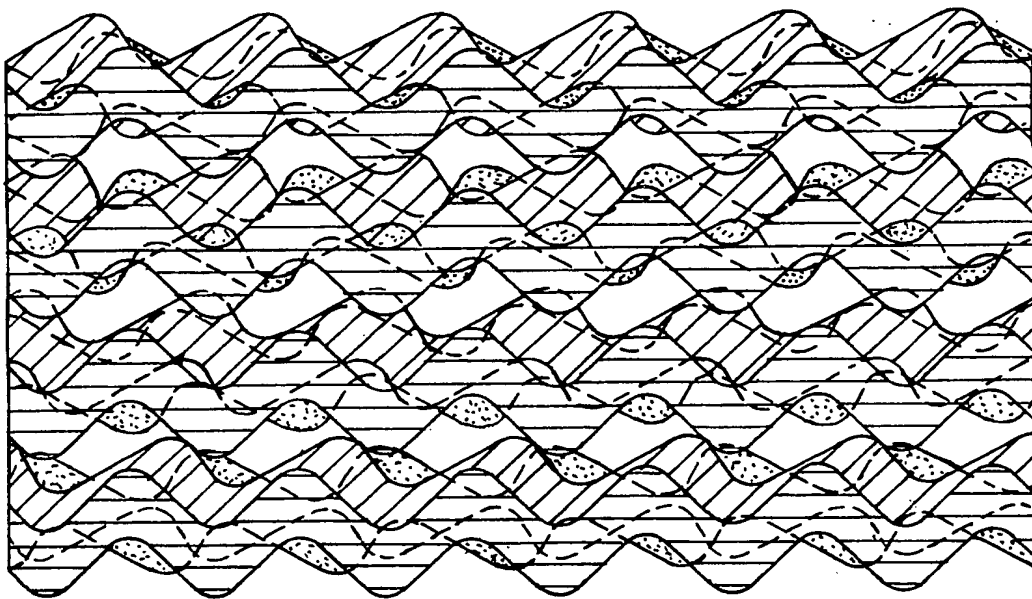


Fig .11 .

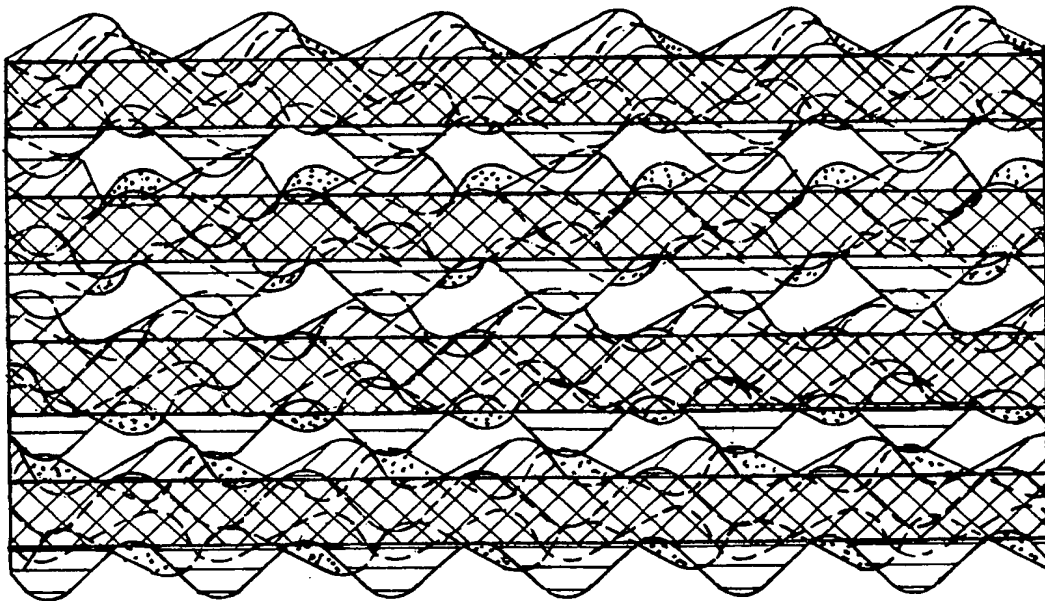


Fig .12 .

SPECIFICATION

Improvements relating to gravure printing

In gravure printing and, particularly in colour printing, a matrix formed by an array of straight parallel engraved lines is used on the printing forme to hold ink and subsequently to apply it to the surface being printed. The depth of each engraved line at any particular point determines the quantity of ink held by the matrix at that point and, in turn, the depth of colour produced on the surface to be printed. A line structure replaces the more conventional dot or cell matrix used more frequently in gravure printing.

When darker tones are to be printed by the forme, the line structure comprises a series of adjacent deep lines and, on printing, the ink from adjacent lines coalesces to give a uniform coating of ink over all of the surface being printed. However, when half tones or lighter tones are to be printed, the line structure has a series of adjacent shallower lines and, on printing, the ink from adjacent lines does not coalesce but, instead, a series of lines spaced from one another are printed on the printing surface with the printing surface showing through between them. Typically, there are ten lines per millimetre, and so, normally, these lines are not resolved by a person viewing the printing so that when the surface is viewed the lines merge to give the appearance of a uniform tone applied over the surface.

In colour printing ink of one colour is overlaid over ink of one or more previous colours on the printing surface and, when each colour is printed using a forme with a line structure, this can lead to various difficulties, particularly when half tones and lighter tones are being printed on top of one another in two or more of the colours. Firstly, it is difficult to arrange for a constant register to occur between the lines of different ink on the printed surface and consequently, when half tones and lighter tones of two colours are printed over one another, the lines of the second colour may be intercalated between the lines of the first colour, or they may overlap partially or totally the lines of the first colour. Where the lines of the first and second colours are intercalated between one another, a person viewing the alternating lines of the first and second colours does not resolve the individual lines but receives the overall impression of a particular colour formed by a simple mixture of the two colours. However, since printing inks are not totally transparent, where there is an overlap between lines of the two colours some portion of the underneath colour is filtered out by the superimposed colour and so, instead of a simple mixture, a different colour impression is received by the person viewing the printed surface. This effect is called colour shift and since the lines are very closely spaced it is very difficult to control the paper feed to get predictable and reproducible results and, in any event, local distortions in the paper can lead to differences in the register between the lines of the different colours during a print run.

Secondly, another defect which can occur is the generation of Moiré patterns. If there is any angular misalignment between the lines printed with ink of one colour and the lines printed with ink of another colour, particularly when the lines are of half tone or a lighter tone, the angular misalignment leads to regions where the lines of different colour intercept one another and overlap other regions where the lines are intercalated. The result of this is the creation of bands or fringes of different colour extending in a direction generally transverse to that of the lines and these bands or fringes are considerably wider and have a much greater spacing than the lines of the matrix. Consequently, they can be resolved readily by a person viewing the printing and they appear as disturbing defects in the final print.

According to a first aspect of this invention, the ink receiving matrix of a gravure printing forme is formed by a number of lines each having a wavy configuration over at least part of its length, with the amplitude of the wavy configuration and the separation of adjacent lines being such that no overlap takes place between them.

When, for example, a printing forme in accordance with this invention is used to print lines having a wavy configuration on top of an array of simple straight lines with both sets of lines being used to print a half tone or a lighter tone so that ink from adjacent lines does not coalesce, some portions of the wavy and straight lines overlap, some portions of both the wavy and straight lines are not overlapped and are merely printed on the printing surface, and some portions of unprinted printing surface remain. When such a surface is viewed by a person looking at it, none of these regions are resolved individually but, instead, a general impression is created of a substantially constant uniform colour. Irrespective of the registration between the straight and the wavy lines there is always an overlap between some regions and no overlap in other regions and thus, as the registration between the two printing formes changes, no colour shift occurs and no Moiré patterns are generated.

Conventionally, inks of three or four different colours are used and applied one on top of the other in colour gravure printing. Preferably the configuration of lines forming the ink holding matrix on three or four printing formes to be used together in three or four colour printing is different with at least two of the formes having lines of wavy configuration. Preferably, for four colour printing, the lines on at least three of the printing formes have a wavy configuration. The differences between the lines on each of the formes having lines with a wavy configuration may be differences in one or more of phase, frequency, shape and amplitude.

One way in which the configuration of the wavy lines may vary from one printing forme to another is for the wavy configuration of the lines on all the printing formes with wavy lines to be completely random in nature. When the lines on all the printing formes are completely random there is an

irregular overlap between printing from the lines of two or more of the printing formes and this completely random and irregular overlap does not give rise to the generation of any Moiré patterns or colour shift. When the wavy configuration of the lines is generally random it is important that the frequency and amplitude of the wavy configuration do not fall below some lower, predetermined values and, to achieve this, it is preferred that the frequency of the wavy configuration of the lines is such that it falls within a predetermined bandwidth range and the amplitude of the wavy configuration is either constant or is again within a limited range.

Alternatively, the configuration of the wavy lines on the printing formes may be selected so that it is different and then, when the different wavy configurations are printed one on top of the other, some portions of the wavy lines overlap with one another whilst other portions do not overlap in an entirely analogous way to the case of the single wavy line and a straight line. It is important that there are no large scale periodic repeats between the lines of different wavy configuration so that there are no periodic bands or fringes formed which are resolvable by the eye of a person viewing the completed printing. This can be achieved by the lines of the wavy configuration having a different wavelength but with such an arrangement care has to be taken to ensure that "beats" between lines of different wavelengths are so close as to not be resolvable by the eye of a person viewing the printing, or, do not occur with sufficient frequency to be present on the completed printing forme. One way of overcoming this is to have the nominal wavelength of the wavy configuration of the lines on all the printing formes with lines of wavy configuration substantially identical. In this case, there is no beat frequency generated between lines printed by different printing formes and consequently, any irregularities in the structures that are created have the same period and spacing as that of the wavelength of the wavy lines. Thus, by ensuring that the wavelength of the wavy lines is sufficiently small so as not to be resolvable, the differences caused by changes in the overlap between lines from different printing formes is not resolvable.

One arrangement which we have found to give very satisfactory results is for the matrix of the first of the printing forms to have a regular wavy configuration all the lines of which are in phase of one another, the matrix of the second printing forme to have lines with a wavy configuration of substantially the same wavelength as the first printing forme but to have a change in phase between adjacent lines so that successive lines gradually lag behind the previous lines in a direction across the second printing forme, the matrix of the third printing forme to have lines with a wavy configuration of substantially the same wavelength as those of the first printing forme but to have a change in phase between adjacent lines so that successive lines gradually

lead the previous lines in a direction across the third printing forme, and the matrix of the fourth printing forme to be formed by an array of plain straight parallel lines. With such an arrangement there is always some overlap between the lines printed by any two or more of the printing formes irrespective of the degree of registration between them. As the configuration of the lines on all the formes are different, there is always some overlapped regions between lines printed by any two formes, some regions which are not overlapped, and some regions not printed. With changes in the registration between lines printed from different printing formes, changes occur in the particular regions which are overlapped but the overall ratio between overlapped, not overlapped and unprinted regions, remains substantially the same. Thus irrespective of slight angular misalignments and transverse alignments, no colour shift or Moiré patterns are produced.

In a preferred arrangement the first printing forme has a wavy configuration formed by a sinusoidal triangular, or somewhat rounded triangular waveform, whereas the second and third printing formes have the configuration of their wavy lines arranged as sheared sinusoidal waves, saw-tooth waves, or slightly rounded saw-tooth waves, respectively. The wave form on the second and third printing formes is preferably arranged so that the phase change between adjacent wavy lines corresponds to that of the shear of the sheared sinusoidal waves or the degree of asymmetry in the saw-tooth waves, so that, adjacent lines of the structure on both the third and the final printing formes are substantially parallel with one another throughout their length and have a substantially constant, uniform spacing.

Preferably the difference in phase between adjacent lines of the second and third formes is in a range between 10° and 80° . It is preferred that the amplitude of the lines having a wavy configuration and their spacing is such that the peaks of the wavy configuration on one side of one line are substantially co-linear with the peaks on the other side of an adjacent line. With the wavy configuration arranged in this way it ensures that when, lines of such wavy configuration are overlapped with straight parallel lines having an equal mark to space ratio, there is a substantially constant amount of overlap and intercalation between the two, irrespective of their position in a direction transverse to the lines. The wavelengths of the wavy configuration is preferably not more than a quarter of a millimetre and typically it is about one fifth of a millimetre. Whilst it is preferred that the swing of the wavy configuration is approximately 50% of the nominal line spacing between adjacent lines on each side of the axis of each line, we have found that when a swing of approximately 40% of the nominal line spacing between adjacent lines is applied to the lines having a wavy configuration there are no bands or fringes formed which are resolvable by the eye. Typically, with a half tone, the width of the

engraved lines is approximately 50μ and such lines have a nominal spacing of approximately 100μ so that there is a substantially equal mark to space ratio between adjacent lines.

A particularly convenient way of preparing a printing forme for gravure printing is by using a laser, or electron beam to evaporate material from a cylindrical printing forme and it is with such apparatus that the present invention finds

particular application. In accordance with another aspect of this invention, a method of preparing a cylindrical gravure printing forme by scanning the surface of the forme with a modulated laser or electron beam to engrave it, includes the step of oscillating the laser or electron beam in a direction transverse to the scanning direction so that the lines engraved in the printing forme by the laser or electron beam have a wavy configuration over at least part of their length.

The intensity of the laser or electron beam is modulated to vary the depth of the line which is engraved into the cylindrical forme and, there is a continual demand to increase the power in the laser or electron beam to enable the deep groove corresponding to full tone to be cut as rapidly as possible. The cutting speed of the laser or electron beam is dependent upon the speed at which the laser or electron beam traverses the surface of the printing forme and thus, the cutting of a path having a wavy configuration requires more energy per degree of angular rotation of the cylinder than the cutting of a straight path. Since colour shift and Moiré patterns only occur for the half tones and lighter tones, it is unnecessary to engrave the lines with wavy configuration where they correspond to full tones. Thus it is preferred that the portions of the lines in the printing forme corresponding to half tones and lesser tones are of wavy configuration whilst the portions of the lines corresponding to a full tone have a plain straight configuration. To achieve this, it is preferred that the amplitude of the oscillatory movement applied to the laser or electron beam is varied in accordance with the intensity of the laser beam.

In laser gravure, the cylindrical printing forme is usually rotated about its axis whilst it is being engraved and the laser engraving head is usually moved along the cylinder in a direction parallel to its axis so that a single, generally helical line is engraved in the surface of the printing forme. In this case the adjacent lines in the pattern engraved in the surface of the printing forme are formed by adjacent turns of the helical path.

An example of a method of preparing a printing forme and, printing formes, in accordance with this invention will now be described with reference to the accompanying drawings; in which:—

Figure 1 is a diagram of the apparatus for preparing a gravure printing forme;

Figure 2 is a diagram showing a modification to part of the apparatus shown in Figure 1;

Figures 3 to 12 all show magnified representations of printed regions obtained by

methods in accordance with this invention; and,

Figure 3 is a print of a half tone region obtained from the yellow printing forme;

Figure 4 is a print of a half tone region obtained from a magenta printing forme;

Figure 5 is a print of half tone region obtained from a cyan printing forme;

Figure 6 is a print of a half tone region obtained from a black printing forme;

Figure 7 shows yellow and magenta half tone regions superimposed on top of one another;

Figure 8 shows yellow and black half tone regions superimposed on top of one another;

Figure 9 shows cyan and black half tone regions superimposed on top of one another;

Figure 10 shows cyan and yellow half tone regions superimposed on top of one another;

Figure 11 shows cyan, magenta and yellow half tone regions superimposed on top of one another; and,

Figure 12 shows yellow, cyan, magenta and black half tone regions superimposed on top of one another.

Cylindrical printing forme 1 is typically formed by a cylindrical substrate covered with a layer of plastics material and this is arranged for rotation about its longitudinal axis. An engraving head 2 receives a modulated laser beam from a modulated laser 3 and focuses it onto the surface of the printing forme 1. As the printing forme 1 is rotated about its longitudinal axis, the engraving head 2 is moved in a direction parallel to the axis of the printing forme so that the engraving head 2 describes a helical path with respect to the printing forme 1. In the engraving head the modulated laser beam from the modulated laser 3 is turned through substantially 90° by a plane mirror 4. In the first example, this plane mirror 4 is pivoted at one side and has its opposite side attached to a piezo-electric transducer 5. The piezo-electric transducer 5 is fed with an oscillating signal which causes it to oscillate and, in turn, oscillate the mirror 4 about its pivot. This oscillation of the mirror 4 leads to a change in the angle through which the laser beam is turned by the mirror 4 and, in turn, leads to the position of the focus spot of the laser beam being oscillated backwards and forwards in a direction parallel to that of the axis of the printing forme 1. Since the printing forme 1 is also being rotated about its longitudinal axis the laser beam engraves a generally helical path around the printing forme 1 but, in addition, the laser beam follows a wavy path and so a line of wavy configuration is engraved in the printing forme 1 by the modulated laser beam. The depth of the line engraved in the printing cylinder depends upon the power of the laser beam and so, as the power of the laser beam varies so does the depth of engraving on the printing forme 1.

Video data from a scanner unit, a disc store or a tape store is introduced into the apparatus on lead 6 with the magnitude of the input on the lead 6 being dependent upon the depth of colour required at that point and hence proportional to the intensity of the laser beam that is required.

The video data is fed into a video amplifier 7 which has an output connected to the modulated laser 3 and a second output leading to a transducer amplifier 8. A radial position encoder 9 is associated with the cylindrical printing forme 1 and has an output formed by a series of pulses each of which represents a predetermined angular rotation of the printing forme 1. The series of pulses from the radial position encoder 9 is fed to a waveform generator 10 which includes a phase change unit including a frequency multiplier. The series of pulses from the radial position encoder 9 are first multiplied by the frequency multiplier by a factor of, for example, 1.0001 to ensure that the signal output from the waveform generator 10 has a frequency which is very slightly different from that of the input signal derived from the radial position encoder means 9 and to ensure that a nonintegral number of wavelengths are generated by the waveform generator 10 for each rotation of the printing forme 1. The waveform generator 10 is preferably arranged to give a symmetrical output, for example a sinusoidal wave or a triangular wave or, an asymmetric output for example a sheared sinusoidal wave or a saw-tooth wave. Figure 1 shows the output of the simple sinusoidal wave. The output from the waveform generator 10 and the output from the video amplifier 7 are combined in the transducer amplifier 8 so that when the input from the video amplifier 7 has a high input, the output from the transducer amplifier is low, and when the input from the video amplifier 7 is low, the output from the transducer amplifier is high and of the same shape and configuration as its input from the waveform generator 10. Thus, the output of the transducer amplifier 8 corresponds to that of the waveform generator 10 with its amplitude modulated and inversely proportional to the output of the video amplifier 7.

In this way, when video data corresponding to half tones and lighter tones is being engraved the modulating signal applied to the piezo-electric transducer 5 has its greatest amplitude whereas when full tones are being engraved very little modulation is applied to the piezo-electric transducer 5.

The waveform generator may be arranged so that the frequency multiplier unit is switched out of circuit when a symmetrical waveform is being generated and be arranged so that a different multiplying factor for example 0.9999 can be switched into the circuit. Thus, when the multiplier is switched out of the circuit, the waveform of the line engraved in the cylindrical printing forme 1 has an integral whole number of wavelengths for each revolution of the printing forme, or alternatively, may have slightly greater than an integral whole number of wavelengths, or slightly less than a whole number of wavelengths so that a gradual lead or lag takes place in the phase of the waveform for adjacent turns of the helix.

In a modification of the apparatus shown in Figure 2, the piezo-electric transducer 5 is replaced by an acousto-optic, or electro-optic

deflector 11 which may be mounted upstream or downstream of the plane mirror 4. In this case, the plane mirror 4 is fixed in position. Acousto-optic deflectors are well known and one suitable for the present application is marketed by Harris Corporation of Melbourne, Florida, 22901, United States of America. The electro-optic deflector that may be used with the present apparatus is described in a paper entitled "The use of a lithium niobate deflector in a 100 picosecond resolution streak camera." by CLM Ireland which was published in Optical Communications, Dec. 1978, Volume 27, No. 3.

Figure 3 shows a print obtained from a printing forme which is made by a method in accordance with the invention in which the frequency multiplier in the waveform generator multiplies the frequency by a number greater than 1 so that each successive line which is engraved on the printing forme 1 lags in phase behind the previous line. Preferably the degree of asymmetry of the saw-tooth waveform and the degree of phase change are associated with one another so that a substantially uniform spacing is achieved between the adjacent lines of the screen as shown in Figure 3.

With the arrangement shown in Figure 4, the frequency multiplier multiplies the frequency by a value of slightly less than 1 so that each successive line of the screen leads its preceding line in phase. Once again, it is preferred that the shape and degree of symmetry of the saw-tooth waveform is matched to that of the lead so that a substantially uniform and constant spacing is achieved between adjacent lines.

Figure 5 shows the wavy lines having a symmetrical waveform in which there is an integral whole number of wavelengths around the printing forme 1 so that each successive line of the pattern engraved on the printing forme 1 is in phase. Once again, in this Figure, the spacing between adjacent lines is substantially constant and uniform. Finally, Figure 6 illustrates a conventional corresponding pattern which is obtained from a conventional laser gravure system in which the printing forme is engraved with a substantially uniform helix. Naturally for such an operation the piezo-electric transducer 5 or the acousto-optic or the electric-optic deflector 11 is disabled.

Any one of the particular waveforms shown in Figures 3 to 6 can be used for any one of the colours in the four colour printing process but we have found that it is convenient to use the waveform as shown in Figure 3 for the printing forme to be used with yellow, the waveform shown in Figure 4 to be used for the printing forme to carry the magenta ink, the waveform shown in Figure 5 to be used for the printing forme to carry the cyan ink and the straight line pattern shown in Figure 6 to be used for the black ink. Typically, the lines in all the patterns have a thickness of the order of 50μ and a nominal separation of 100μ so that, for a half tone, the

12. A method of preparing a cylindrical gravure

mark to space ratio between the lines is substantially unitary.

Figures 7 to 12 illustrate the way in which impressions from more than one printing forme overlap and illustrate how the printing formes in accordance with this invention and those made by a method in accordance with this invention avoid problems with colour shift and Moiré fringes. Figure 7 shows the pattern of Figure 3 overlaid on that of Figure 4 and illustrates how portions of the two patterns overlap one another, how portions are only a single layer deep and how portions of the printing surface show through between the two patterns. As one pattern is moved relative to the other in a direction transverse to their longitudinal axes, whilst the particular shape of the overlapping and unprinted portions varies there is substantially the same ratio of overlapped regions to single printed regions to unprinted regions. Thus, irrespective of the relative position of the two patterns in a direction generally transverse to their longitudinal axes, or for that matter in a direction along their longitudinal axes, a substantially constant colour impression is created to a person viewing the resulting mixture of patterns and consequently no problems of colour shift or Moiré fringes are produced.

Figure 8 shows a mixture of the patterns shown in Figures 3 and 6 and once again illustrates that the areas of overlap, the areas of single printing and the areas of blank unprinted printing surfaces are substantially constant. Figure 9 shows the patterns of Figures 5 and 6 overlapped on top of one another and again illustrates that there is a substantially constant ratio of the overlapped portion, to the single printed portion to the unprinted portion. Figure 10 shows a mixture of the patterns of Figure 3 and Figure 5 and whilst the phase relationship between the peaks and troughs of the two wavy lines varies with their relative phase there is still a substantially constant impression obtained by a person viewing such a mixture of pattern.

Finally, Figure 11 shows the patterns of Figures 3, 4 and 5 all overlaid on top of one another. Finally, Figure 12 shows the patterns from Figures 4, 5 and 6 all overlaid on top of one another.

CLAIMS

1. A gravure printing forme including an ink receiving matrix formed by a number of lines each having a wavy configuration over at least part of its length, with the amplitude of the wavy configuration and the separation of adjacent lines being such that no overlap takes place between them.

2. A set of gravure printing formes for at least three colour printing includes at least two formes having their ink holding matrices formed by lines with a wavy configuration, the wavy configuration of the lines on the at least two printing formes being different from one another.

3. A set of printing formes according to claim 2, in which the lines having a wavy configuration on

the at least two printing formes are different in one or more of phase, frequency, shape and amplitude.

4. A set of printing formes according to claim 2 or 3, in which one printing forme has an ink holding matrix in the form of an array of straight parallel lines.

5. A set of printing formes according to claim 2, 3 or 4, in which the matrix of the first of the printing formes has a regular wavy configuration, all the lines of which are in phase of one another, the matrix of the second printing forme has lines with a wavy configuration of substantially the same wavelength as the first printing forme but with a change in phase between adjacent lines so that successive lines gradually lag behind the previous lines in a direction across the second printing forme, the matrix of the third printing forme has lines with a wavy configuration of substantially the same wavelength as those of the first printing forme but with a change in phase between adjacent lines so that successive lines gradually lead the previous lines in a direction across the third printing forme, and the matrix of the fourth printing forme is formed by an array of plain straight parallel lines.

6. A set of printing formes according to claim 5, in which the first printing forme has a wavy configuration formed by a sinusoidal triangular, or somewhat rounded triangular waveform, and the second and third printing formes have the configuration of their wavy lines arranged as sheared sinusoidal waves, saw-tooth waves, or slightly rounded saw-tooth waves, respectively.

7. A set of printing formes according to claim 6, in which the waveform on the second and third printing formes is arranged so that the phase change between adjacent wavy lines corresponds to that of the shear of the sheared sinusoidal waves or the degree of asymmetry in the saw-tooth waves, so that, adjacent lines of the structure on both the second and third printing formes are substantially parallel with one another throughout their length and have a substantially constant, uniform spacing.

8. A set of printing formes according to claim 6 or 7, in which the difference in phase between adjacent lines of the second and third formes is in a range of between 10° and 80° .

9. A set of printing formes in accordance with any one of claims 2 to 8, in which the amplitude of the lines having a wavy configuration and their spacing is such that the peaks of the wavy configuration on one side of one line are substantially co-linear with the peaks on the other side of an adjacent line.

10. A printing forme according to claim 1, or one of a set of printing formes according to any one of claims 2 to 9 and having lines with a wavy configuration, in which the wavelength of the wavy configuration is not more than a quarter of a millimetre.

11. A printing forme according to claim 1, substantially as described with reference to Figures 1 to 5 of the accompanying drawings.

printing forme by scanning the surface of the forme with a modulated laser or electron beam to engrave it, characterised in that it includes the step of oscillating the laser beam in a direction
5 transverse to the scanning direction so that the lines engraved in the printing forme by the laser beam have a wavy configuration over at least part of their length.

10 13. A method according to claim 12, further characterised in that the portions of the lines engraved in the printing forme which corresponds

to half tones and lesser tones have a wavy configuration whilst the portions of the lines
15 corresponding to full tones have a plain straight configuration.

20 14. A method according to claim 12 or 13, further characterised in that the amplitude of the oscillation of the laser or electron beam is varied in accordance with its intensity.

15. A method according to claim 12, substantially as described with reference to the accompanying drawings.

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